1996

A Review of the Causes and Treatment of Low Back Pain during Pregnancy

Dana Krenzel
University of North Dakota

A REVIEW OF THE CAUSES AND TREATMENT OF LOW BACK PAIN DURING PREGNANCY

by

Dana Krenzel
Bachelor of Science in Physical Therapy
University of North Dakota, 1995

An Independent Study

Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine

University of North Dakota

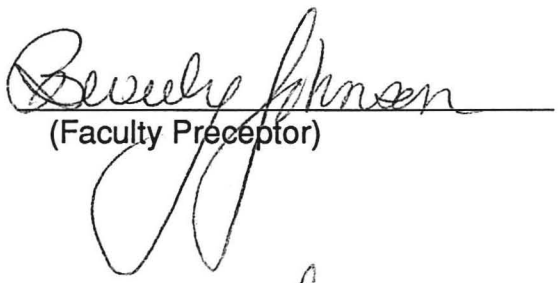
in partial fulfillment of the requirements

for the degree of

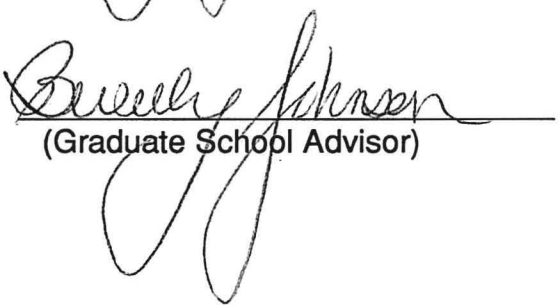
Master of Physical Therapy

Grand Forks, North Dakota
May
1996

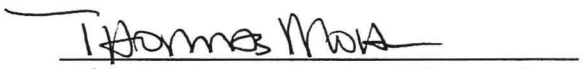
This Independent Study, submitted by Dana Krenzel in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.



(Faculty Preceptor)



(Graduate School Advisor)

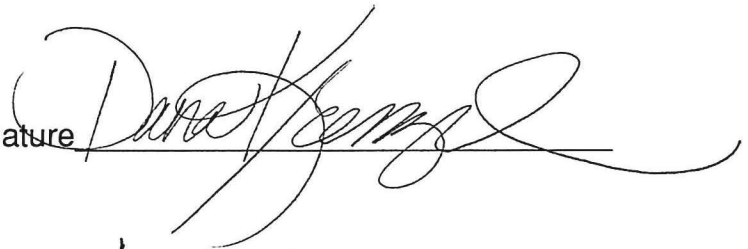


(Chairperson, Physical Therapy)

PERMISSION

Title	A Review of the Causes and Treatment of Low Back Pain During Pregnancy
Department	Physical Therapy
Degree	Master of Physical Therapy

In presenting this Independent Study Report in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Department of Physical Therapy shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work or, in her absence, by the Chairperson of the department. It is understood that any copying or publication or other use of this independent study or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and the University of North Dakota in any scholarly use which may be made of any material in my Independent Study Report.

Signature 

Date 4-23-96

TABLE OF CONTENTS

LIST OF TABLES

ACKNOWLEDGMENTS

> The best and most beautiful things in the world cannot be seen or touched, but are felt in the heart . . . .
>
> Helen Keller

As I reflect on my college years, my heart is filled with appreciation and love. I want to thank my parents, family, and friends for all of their support, encouragement, and prayers. You sustained me through the hard times and laughed with me when times were good, creating moments I will always treasure. Thank you.

ABSTRACT

Pregnancy is a time of great musculoskeletal change for a woman. Complaints of low back pain are a very common occurrence at this time. Many women regard this type of pain as a normal adjunct to pregnancy. However, most types of low back pain related to pregnancy are either treatable or avoidable. Mechanical, hormonal, and vascular factors may all contribute to low back pain. Differentiation of these different causes of low back pain is crucial to providing the patient with effective intervention plans. Physical therapists can provide evaluation, treatment, and low back pain management techniques to the expectant mother. Exercise, patient education, various modalities, manipulation, and/or the use of an orthosis outline possible treatment options. The purpose of this study is to provide physical therapists with information pertaining to the causes and treatment of low back pain. This knowledge will enable physical therapists to provide clinical management and prevention throughout the course of pregnancy.

CHAPTER I

INTRODUCTION

As a woman progresses through the course of pregnancy, her body undergoes many significant changes. Alterations in the musculoskeletal system are only one of many that occur. Most pregnant women consider low back discomfort as a normal and even expected portion of pregnancy. In fact, a backache is the most common orthopedic complaint during pregnancy.[1]

Most authors agree that about 50% of pregnant women experience low back pain,[2-8] while another[9] claims that nearly 100% suffer from some type of low back discomfort. Usually back pain during pregnancy is a mild and self-limited process,[10] but this pain can become so severe that it can be classified as disabling, especially during the last trimester.[11] One study reports that activities of daily living are limited in twelve percent of women experiencing low back pain during pregnancy.[12] Low back and posterior pelvic pain also account for the majority of sick leave during pregnancy.[4]

Despite the high incidence of low back pain in pregnancy, this problem is sparsely documented and researched.[13] Confusion dominates the literature in regard to risk factors associated with low back pain in pregnancy. A wide variety of risk factors related to low back discomfort exist. They consist of low

socioeconomic class, low back pain occurring before the first pregnancy, previous and interim pregnancy related low back pain, heavy labor, smoking, parity, and age.[3,4,12,14] There are also a number of factors not related to low back discomfort during pregnancy including age, race, parity, occupation, weight of the baby, amount of maternal weight gain, number of prior pregnancies, exercise habits or fitness level, sleeping positions, mattress types, maternal height, weight, or body mass index, and previous history of low back pain.[2,3,10]

Physical therapists can provide the expectant mother suffering from low back pain a medley of options to decrease or even prevent some of her pain. The use of patient education, exercise, modalities, manipulation, and an orthosis outline a few choices available to pregnant women. Before implementing any kind of physical therapy intervention, an understanding of possible etiologies and general processes of pregnancy along with an appropriate evaluation are necessary. By providing an accurate, complete, and educated approach to evaluation and treatment, personal and financial consequences of pregnancy related low back pain can be diminished.

CHAPTER 2

ETIOLOGY

There are many causes of low back pain among pregnant women. Three major etiologies include hormonal, mechanical, and vascular causes. A handful of rare diagnoses can also manifest themselves as low back pain. Each cause will be defined and described as well as broken down into subtitles.

Hormonal

A woman's body is subject to many alterations during pregnancy, including hormonal changes. Most authors single out an increase in the hormone, relaxin, as a cause of sacroiliac and/or back pain.[3,11,15-24] Other authors point to an increase in the combination of both relaxin and estrogen.[9,25-27] The relationship between low back pain and fluctuating hormonal levels is not a new idea; Hippocrates called it "disjunctio pelvica."[3]

Relaxin is an ovarian polypeptide hormone, which is related to insulin and secreted by the corpus luteum and decidua of pregnancy.[1,2,16,21,23,28] Increased levels of relaxin cause an increased laxity of all the ligaments in the body. The ligaments most commonly involved are located at the public symphysis and sacroiliac joints (SIJs). Authors disagree on the timing of the hormonal fluctuation. Wilder[29] and Rungee[3] report peak levels reached in the first

trimester, while others[19,30] report the level to continuously rise throughout pregnancy.

Relaxin decreases the strength of collagen,[11,26] thus softening the rigid posterior and anterior sacroiliac ligaments and the pubic symphysis of the pelvis.[6,9,10,22] This softening is specifically caused by an increase in both water and alkaline phosphate concentrations at the symphysis pubis.[17]

Weakening of the pelvic ligaments in combination with the small, flat shape of a woman's SIJs allows an increased incidence of sacroiliac pain and instability.[31,32] Hypermobility at the SIJs comes in unison with hypermobility at the pubic symphysis.[32] Additionally, the fibrocartilage which lines the pelvic articulations softens allowing increased mobility.[33] Normal ligamentous tension and pelvic configuration returns within two to five months after delivery.[3,9,19]

The implications of the combined laxity and increased mobility result in distention of the pelvic joints permitting rotary movements at the SIJs.[9] This characteristically unstable pelvis facilitates the birth of the child.[6] The iliac bones rotate forward creating an increase in the diameter at the brim antero/posteriorly. The rotations can also take place in the opposite direction, leading to an increased outlet antero/posteriorly.[15,22] Back pain is primarily caused by rotation of the SIJs.

Precise radiologic studies give convincing evidence to the widening of the pelvic joints.[9,29] The symphysis pubis can widen 1-12 mm with an average being 5mm. Expansion of the SIJs occurs also but to a lesser extent of 2-3mm.[29] One

might attribute many of these changes to posture and weight of the fetus, but sacroiliac symptoms commonly occur in the first trimester before the woman knows she is pregnant or before the size and weight of the fetus can play a significant role.[3,22]

Mechanical

Posture

The erect posture of humans is not a congenital characteristic but an accomplishment that must be acquired by each person.[9] This is an enactment that can be viewed by watching an infant try to walk or stand. An infant is born with a straight spine that acquires curves as he/she becomes an upright individual. Through development, the spine becomes hyperextended in the cervical and lumbosacral regions. These extended portions of the spine are stabilized by the sacrospinalis muscle groups with only the rectus abdominis musculature resides to counter the extension forces.

This extension force causes man's center of gravity to be displaced posteriorly. These stresses are absorbed by the posterior intervertebral disks and apophyseal articulations of the lumbar and cervical spine.[9] With this in mind, imagine how pregnancy will further complicate this picture! The pregnant woman's center of gravity is pulled anteriorly. She will present herself with her shoulders back, straight head and neck, and an increased lumbar lordosis. Shakespear described this particular posture as "the pride of pregnancy."[9]

Vigorous postural changes occur throughout the 40 weeks of pregnancy. As the fetus grows, the uterus and breasts become enlarged displacing the woman's center of gravity forward[1,3,6,9,25,34] and onto her toes.[19] To maintain an upright and balanced posture, the woman must compensate by changing her posture. Alterations may include a forward head, hyperextended knees, rounded shoulders, increased thoracic kyphosis, and increased lumbar lordosis. The latter is associated with an anterior pelvic tilt and compression on the posterior vertebral structures. Flattening of the lumbar region may also occur.[1]

Any change in the kinematic spinal chain reduces the biomechanical efficiency of the surrounding anatomical structures including the muscles, ligaments, and disks.[1] Normally, the abdominal muscles work together with the paraspinal musculature and ligaments to stabilize the pelvis during weight transfers from the upper extremities to the lower extremities. A vertically balanced spine is characterized by minimal muscle activity of the paraspinal musculature as can be demonstrated by small contractions recorded by EMG studies.[1] Changes in weight distribution increases paraspinal activity and axial compression loads on the spine. This can easily be demonstrated when a pregnant woman reaches her arms forward with her hips flexed. Excessive muscular forces produced will lead to microtrauma of connective tissue in the trunk extensor musculature.[26]

As the uterus grows, it stretches the abdominal wall and weakens the surrounding muscles.[3,10,36] Support of both the fetus and the pelvic organs is

intimately related to the quality and strength of the abdominal muscles. A study done by Fast[12] demonstrated the inefficiency of the abdominal muscles during pregnancy. Approximately 86% of pregnant women could not complete one sit-up versus only 11% of nonpregnant women. Due to the weakness and extended length of the abdominal muscles, the paraspinals are expected to support the spine even though they are at a biomechanical disadvantage due to their shortened length.[10] This disadvantage causes the paraspinal muscles to become shortened and taunt.[6] Consequently, the paraspinals will fatigue easily and increased stress will be placed on static structures, such as the ligaments and disks.[1]

In addition to pure muscular changes, hormonal fluctuations confounded with muscular imbalance due to poor posture causes pelvic insufficiency. "Pelvic insufficiency" is a clinical syndrome occurring in the latter half of pregnancy. It incorporates both hormonal and muscular changes.[9] A decrease in pelvic joint stability along with muscular imbalance causes rotation of the SIJs and results in low back pain. For instance, the pelvis rotates forward due to relaxin and muscle imbalance. This places the hamstrings in a stretched position and the hip flexors in a shortened position. Ultimately these altered muscular postures result in low back pain.

Although one can readily see how the posture of pregnancy can cause low back pain, it should be remembered that this dilemma is multifactorial.[3,25,27]

Some researchers have not been able to significantly correlate postural changes with low back pain.

Diastasis Recti

The definition of diastasis recti is the separation of the rectus abdominis muscle.[29] The mechanism may involve the widening of the linea alba via relaxation of tissues or true separation.[36] "Stretch weakness is the effect on muscles which comes from their remaining in an elongated position beyond the neutral physiologic resting position."[29] Noble[37] believes that both hormonal and biomechanical changes predispose pregnant women to diastasis recti, although this diagnosis is not exclusive to pregnant women. The increasing size and weight of the fetus places added stress on the abdominal wall. The uterus will increase in weight from 50 g to 1000 g at full term! As one might expect, the incidence of diastasis recti increases as the fetus grows. Peak incidence occurs during the third trimester with an estimated 66% of women experiencing diastasis recti.[3,36]

Other possible causes of diastasis recti include obesity, multiple pregnancy, pendulous abdomen from a former pregnancy, or an overabundance of fluid in the uterus.[37] Ethnic differences exist, with a higher incidence of diastasis recti occurring in blacks as compared to nonblacks.

The abdominal wall musculature plays a dramatic role in the maintenance of a healthy lumbar spine.[38] Noble[37] indicates that the rectus abdominis is an important muscle to control pelvic tilt. Any deviation of the abdominal

musculature (internal and external oblique, transversus abdominis, and rectus abdominis) or the rectus sheath may theoretically decrease the ability of this musculature to adequately support the back.[36] Mechanical low back pain can be attributed to this compromised support from faulty posture and abnormal trunk mechanics.[2,29]

The size and location of the diastasis recti varies with each woman.[37] Normally, there are about 2 mm between the bodies of the rectus abdominis. Separation of the rectus abdominis occurs mostly at the naval region but is not limited to this area.[37,39] The distance between the two bodies in a woman suffering from diastasis recti may be small or so severe that the abdominal contents can be felt protruding through the space. Again, decreased abdominal efficiency will certainly result leading to abnormal posture and the accompanying dysfunctions including low back pain.[29]

Vascular

A common cause of nocturnal back pain during pregnancy has been sighted as a vascular problem.[40] Nocturnal back pain is reported by about 60% of all pregnant women and is associated with sleep disturbances.[41] Reports suggest that sleep disturbances lead to musculoskeletal disturbances which may exacerbate pain.[42] Pregnant women experience decreased sleep efficiency even though time in bed was higher when compared to a group of nonpregnant women.[43]

Discomfort usually occurs one to two hours after the woman has laid down to sleep.[42] In the supine position, and occasionally in the sidelying position, the enlarged uterus of late pregnancy occludes the vena cava[42] and the common iliac veins.[44] Compression of the vena cava causes a decreased cardiac output. This also causes congestion of veins draining into the vena cava.[42] The result is a stasis and increased pressure within the vertebral bodies and pelvic circulatory mechanisms. Some patients have adequate collateral circulation and will avoid these unfortunate changes. If good collateral circulation is absent, disturbances in nutrition, oxygen supply, and removal of waste product from neural tissues takes place resulting in pain.

Other

Less common causes of back pain during pregnancy include[3,10,11,25]:

1) congenital anomalies such as spondylolisthesis and spondylolysis
2) vertebral fractures due to transient osteoporosis
3) acute sprains
4) tumors
5) infections
6) arthritis
7) herniated nucleus pulposus
8) pressure on lumbosacral plexus
9) abdominal or pelvic pathologies

Complaints and symptoms experienced can range from mild to very severe.[3] All of these potential causes of low back pain are rare, but they should be ruled out in the cases of prolonged treatment resistance.

CHAPTER III

DIFFERENTIATION OF LOW BACK PAIN

Before treating a pregnant woman complaining of low back pain, the physical therapist must complete a thorough evaluation. It is extremely important to obtain a good medical history because many non-orthopedic problems can manifest themselves as low back pain.[3] Once the history has been concluded, the evaluation should continue with a complete physical back examination. To aid in the effectiveness of the physical exam, Magee[45] identifies separate categories to investigate. The divisions of the objective examination include: observation, bony palpation, soft tissue palpation, range of motion, neurologic exam, and appropriate special tests.

Good observation skills should be utilized to allow a thorough physical examination.[45] Observing gait and transfer abilities may provide vital information regarding pain, willingness to move, and attitude. Posture requires a discriminating look. The lumbar spine and pelvic regions should be examined carefully. Pay close attention to pelvic tilt and any tenderness of the back musculature.

Bony palpation requires inspection of the anterior and posterior iliac spines, greater trochanters, and iliac crests.[38,45] Soft tissue palpation will include

abdominal, hip flexor, paravertebral, and gluteal musculature. Range of motion for the entire spine, bilateral hip joints, and bilateral knee joints should be assessed. Myotomes, dermatomes, and sensation should be assessed in the neurologic portion of the exam. Finally, special tests will aid the physical therapist in completing the full physical examination.

It is important to recall that non-orthopedic conditions can present themselves as backaches.[3] Patients complaining of increased vaginal discharge, pelvic pressure, menstrual cramps, and/or uterine contractions should be immediately referred to an obstetrician. The symptoms mentioned above may indicate premature rupture of membranes or pre-term labor.

The urinary system can also contribute to the list of non-orthopedic causes of backaches.[3] Symptoms, including flank pain along with urgency, abdominal pain, dysuria, nausea, and/or vomiting, may indicate problems with this system. Resultant diagnoses could be hydronephrosis, pyelonephritis, or renal calculi. Again, the patient should be referred for a prompt obstetrical opinion.

Ligament relaxation contributes to SIJ dysfunction during pregnancy. Common signs and symptoms associated with SIJ problems include persistent pain that can vary from mild to severe in description.[46] Pain may present as unilateral or bilateral SIJ articulations[3,11,22,46] and can also include discomfort at the pubic symphysis.[9] Sacral iliac joint pain is usually located on the sacrum or 4 cm lateral and inferior to the affected posterior superior iliac spine.[3] This type

of back pain may or may not be associated with a radicular component. If radiating pain is present, it may travel to one or both buttocks, but it usually does not radiate into the leg in a sciatic distribution.[46] The intensity of the pain will increase with standing and walking and will only be unsubstantially lessened with the acquisition of a recumbent position.[3,46] Manual compression and/or distraction of the pelvis by the therapist will also increase pain.[11,46]

Soft tissue palpation may reveal tenderness at the pubic symphysis[9] and spasm of the paraspinal muscles.[22,45] Bony tissue palpation of both anterior superior iliac spines (ASISs) should be performed with the patient in a supine position so as to eliminate the possible effect of a leg length discrepancy.[22] One ASIS positioned higher than another may indicate a problem at the SIJ.

Also in the supine position, Baer's Point can be assessed for pain. This is a point of tenderness lateral and inferior to the umbilicus on the painful side. It is located about one-third of the way between the umbilicus and the ASIS.[22,45] Tenderness at Baer's Point indicates a sprain of the painful sacroiliac ligament, spasm and/or tenderness of the iliacus, or the presence of an infection.[45]

Special tests are an important diagnostic tool, especially when attempting to confirm problems at the SIJs. An excellent test to begin this portion of the exam is the unilateral and bilateral straight leg raise (SLR).[45] These SLR tests are done passively by the therapist. At 70° of a unilateral SLR, the nerve roots of the sciatic nerve are stretched maximally. Therefore, the patient is pain free at 70° and the sciatic nerve and its roots are cleared of pathology. However, if

pain occurs after 70° of an unilateral SLR, then the SIJs or the lumbar spine is implicated. When both unilateral SLRs produce pain, then a bilateral SLR should be performed. Pain occurring before 70° of this bilateral SLR indicates SIJ dysfunction.

Once the SIJ has been identified as the source of dilemma, more specific special tests can be completed. Table 1 explains and describes the following special tests: Patrick's or FABER, Gapping, "Squish," Supine-to-Sit, and Approximation.

Mechanical or postural dysfunctions can also cause back pain during pregnancy. One author states, "Nearly all the backaches of child bearing are postural in origin."[47] The forward tilting of the pelvis, which displaces center of gravity anteriorly, is the main contributing factor to mechanical low back pain.[9] Observation will reveal hyperlordosis accompanied by tenderness, fatigue, or muscular strain of the paravertebral structures.[3,10,48]

Pain generally occurs during the latter half of the pregnancy.[3,9,11] It is present upon rising in the morning and increases as the day goes on.[11,48] Some relief may be achieved with recumbency. Radicular pain may or may not be present[3,48] as well as possible pain at the pubic symphysis.[27] One researcher states that many pregnant women suffering from mechanical back pain had a prior history of hyperlordosis and/or back pain.[48]

Mechanical back pain may also be due to insufficient support of the back by the abdominal muscles. Diastasis recti can be implicated at any time of the

Table 1.--Description of SIJ Special Tests[22,45]

Test	Description
Patrick's or (FABER)	Patient in supine position with heel of affected side placed on the opposite knee while simultaneously externally rotating the hip. (+) The test is positive if pain is provoked indicative of SIJ or hip joint Pathology.
Gapping	Patient in supine position. Examiner applies pressure, with crossed arms, in a downward/lateral direction to bilateral ASISs. (+) The test is positive if unilateral gluteal or posterior leg pain is yielded.
"Squish"	Patient in supine position. Examiner applies downward and medial pressure to bilateral ASISs. (+) Test is positive if pain is produced.
Supine-to-Sit Test	Patient in supine hooklying position. The patient is instructed to do 1-3 independent bridges. The examiner passively extends both legs and places his/her thumbs on the inferior border of both medial malleoli. The patient is then assisted to a long sitting position and the position of the medial malleoli are compared again. (+) Test is positive if there is a significant change in functional leg length between the two positions.
Approximation	Patient is in sidelying position. Examiner applies a downward pressure to the upper part of the iliac crest. (+) Test is positive if the patient experiences increased pressure at the SIJs.

pregnancy by completing a special test.[37] The patient should assume a hooklying position and raise her head and shoulders eight inches from the supporting surface. She should keep her chin tucked and her arms stretched out to the front. The examiner will palpate along the entire length of the linea alba and note any bulge.[29,37] A positive test is indicated by a separation of the rectus abdominis muscle bellies, measuring at least three finger widths in diameter. If a positive test is elicited, the patient should not perform any curl up or leg lowering exercises.

Recently, researchers have defined a separate category of low back pain, calling it posterior pelvic pain.[4,48] The reason for this pain is unknown, and the cause is not anatomically specific. It is associated with a set group of symptoms and can be identified by a special test called the posterior pelvic pain provocation test.

Symptoms of posterior pelvic pain include a history of time and weight bearing related pain located deep in the gluteal muscle area or at the posterior pelvis.[48] The pain distribution is located distal and lateral to the L_5-S_1 junction. It can be described as deep and/or stabbing with or without radiation to the posterior thigh and knee. If radiation occurs, it rarely travels to the calf and never to the foot. There will be an absence of a nerve root syndrome and she will demonstrate unobstructed movement of the spine and bilateral hips. Difficulty due to pain will be experienced in bed mobilities, such as rolling. The patient will also report intervals of time where she is free of any pain.

Pregnancy offers a first time experience for posterior pelvic pain, and it will normally disappear within six months after delivery.[4]

Authors have formulated a special test to identify patients suffering from posterior pelvic pain.[4,48] The posterior pelvic pain provocation test is performed with the patient in the supine position and the affected hip flexed to 90°.[4] The examiner will stand on the side to be tested. A light manual pressure is applied through the longitudinal axis of the femur via the surface of the flexed knee. The examiner will also need to simultaneously stabilize the pelvis by placing his/her hand on the contralateral ASIS. A familiar and well localized deep gluteal pain demonstrates a positive test. The specificity of the posterior pelvic pain provocation test is 80% and the sensitivity is 81%.[4]

Pubic symphysis pain is very weakly correlated with posterior pelvic pain.[4] A review of pelvic anatomy, however, reveals that pubic symphysis pain cannot occur without posterior pelvic problems, even if they are minor.

> The concept "posterior pelvic pain" as defined here allowed us to work with a group of women who had been classified as having "SI pain," SIJ syndrome," or "pelvic girdle relaxation." These concepts should be omitted because they indicate that the pain is caused by a specific anatomic structure or is related to increased movement in the pelvic ring, neither of which is true.[4]

Vascular causes of back pain are unique. Pain occurs nocturnally and usually begins one to two hours after the woman has retired to bed.[40,42] The supine position and occasionally the sidelying position may elicit vascular pain. This pain is due to the increasing weight of the uterus placing compressive

forces on the vena cava. At this time, no specific physical therapy geared special tests are known for the identification and/or differential diagnosis of vascular pain.

One might assume all pregnancy-related low back pain is the same. This chapter has differentiated four types of back pain and has given examples of possible non-orthopedic causes of low back pain. A careful evaluation is extremely important in the identification of non-orthopedic concerns requiring obstetrical referral, thus assuring the highest level of patient safety possible. An appropriate differential diagnosis is important in order to provide the patient with maximally effective treatment plans, home exercises, or preventative measures.

CHAPTER IV

PHYSICAL THERAPY MANAGEMENT AND TREATMENT OF LOW BACK PAIN

Physical therapists can provide a wide variety of options to women experiencing low back discomfort. Management of low back pain may include one or a combination of the following: therapeutic exercise, patient education, rest, manipulation, modalities, or the use of an orthosis.

As physical therapists, we can suggest a diversity of exercises to pregnant women. Some categories of exercise include stretching, strengthening, and an overall cardiovascular fitness program. Careful instruction and explanation are requirements a physical therapist needs to meet to ensure patient safety upon prescribing any exercise regimen.

Stretching Exercises

Stretching is an important aspect of therapeutic exercise for the pregnant client. Stretching exercises will help maintain joint and muscular balance as posture changes during pregnancy. Authors identify specific muscles prone to tightness due to dysfunction; they include the gastrocnemius/soleus, posterior tibialis, short hip adductors, hamstrings, rectus femoris, iliopsoas, tensor fascia latae, piriformis, erector spinae, and the quadratus lumborum.[29,49] Common

goals for this type of exercise are the prevention of contractures and the decrease in low back pain.[9] The patient can meet these goals by performing careful passive stretching. In providing the patient with effective stretching techniques, positioning needs to ensure proper stabilization and protection of the spine.[29] Pregnant women should not encounter pain with stretching[29] and should never use ballistic movements.[9]

The gastrocnemius/soleus complex can be stretched in the standing position via a lunge position or with the use of step.[9,29,37] The calf musculature can also be stretched by a partner who dorsiflexes the ankle while maintaining knee extension as the patient either sits or lies in the supine position.[29,37]

Hip adductors can be stretched in a seated position with the soles of the feet placed together.[29] The patient should be instructed to maintain a neutral pelvic tilt. She also might find it helpful to place a pillow under each thigh to support them, allowing a gradual stretch.[29,50] This butterfly position can also be done in a supine position during the first trimester, again maintaining a neutral pelvic tilt.

A number of methods exist for stretching the hamstrings.[29] The supine position can be utilized during the first trimester. The patient flexes the hip to 90° and holds onto the posterior thigh with both hands as she attempts to extend her knee. The opposite leg is stabilized by performing an isometric contraction of the quadriceps. Standing bilateral hamstring stretching can be accomplished by completing the wall stretch. The patient will need to face a wall and bend at

the waist placing her palms against the wall. While keeping a relatively neutral low back posture and her quadriceps tight with an isometric contraction, the spine is actively elongated by pushing the ischial tuberosities superiorly and posteriorly.[50] The hamstrings can also be effectively stretched in a seated position. The patient sits at the edge of a chair with the leg to be stretched positioned out in front of her and the heel in contact with the floor and the knee extended. The other leg is kept in the 90-90 position with the whole foot flat on the floor. She will place one hand on the extended knee and reach forward to the ankle with the other hand.[9]

Hip flexor musculature may be stretched using the Thomas test position when the supine position is still tolerated (first trimester).[29] As the pregnancy progresses, effective hip flexor stretching can be accomplished utilizing a half kneeling position. She will kneel on the side to be stretched and use one hand on her own buttock to facilitate a gradual contraction to begin the hip flexor stretch as she pulls forward with the contralateral leg. It is very important to remind the patient to maintain a posterior pelvic tilt during this stretch because slight lumbar flexion must be attained for an effective stretch.

Tensor fascia latae stretches can be performed in a standing position.[29] She will stand with the side to be stretched toward the wall, and will then cross the leg behind the contralateral leg. Then she will lean toward the wall until her hand or forearm rests against the wall. While keeping her trunk straight, she will lean her hip toward the wall and bend the front knee.

The piriformis can be stretched while in a seated or supine position by flexing, adducting, and internally rotating the hip.[29] The spine needs to be kept in a neutral position with the pelvis level. If done in the supine position, stabilization is achieved by performing an isometric quadriceps contraction.

Muscles of the thoracolumbar area can be stretched in a couple ways.[29] The prayer stretch is done by having the patient sit back on her heels from a four-point position. As pregnancy progresses, she will need to abduct her legs to make room for the uterus. The patient can also perform the cat-back stretch, otherwise called the posterior pelvic tilt or pelvic rocking maneuvers. This exercise is also done in the four-point position and the patient tries to round her back (trying to get her ribs closer to her hips) while flexing her neck. During an exhalation, the abdominal muscles are tightened and, at the same time, the pelvis is pulled down due to gluteal contractions, thus decreasing the lumbar spinal angle curve. This position should be held three to five seconds while she maintains a normal breathing pattern.[33]

"Pelvic rocking, or the pelvic tilt, is the most important exercise for pregnant women to learn."[33] The pelvic tilt can be performed while standing against a wall or in a supine position.[6,34,51] Benefits of pelvic tilt exercises include: strengthening of back and abdominal musculature, improved circulation to the pelvis and legs, an aide in prevention of varicose veins and hemorrhoids, increased pelvic mobility, tension relief, and relaxation.[52]

Strengthening Exercises

Common deficits in strength occur in the gluteus maximus, gluteus medius, abdominal, lumbar paravertebrals, and occasionally the quadriceps musculature.[29] To support the vulnerable joints of the pelvis, strengthening exercises for the gluteus maximus and medius should be performed throughout the entire pregnancy. During the first trimester, supine bridges are very effective whether the exercise is performed with both knees extended and supported on a slightly elevated surface (low stool) or with both knees flexed and feet flat on the supporting surface.[29,37] Hip extension exercises may also be done in a standing position while holding onto the back of a chair or other sturdy surface for support. The patient will thrust her leg posteriorly, extending the hip and then holding the foot off the floor for five seconds. Hip extension exercises can also be performed in the four-point position, but care must be taken to maintain a neutral pelvic position. The patient needs to slowly sink about halfway to the floor diagonally toward one hip until she feels a contraction in the gluteus medius area. At this time, she should move part way back to the starting position and again into the hip-sink position, repeating several times after returning to neutral.

The safest abdominal strengthening exercise pertinent to a pregnant woman is probably the posterior pelvic tilt done in the four-point position (cat-back stretch). Traditional sit-ups and double leg lifts are discouraged during pregnancy because they put undue stress on the abdominal and back muscles

respectively.[6] Shearer[53] reports that the pelvic tilt exercise primarily strengthens the external oblique muscles.

In the first trimester, the pregnant client may do supine leg slides or a head and shoulder lift. However, if diastasis recti is present, the patient will need to support her abdomen as she performs this exercise by using her wrists and cupped hands to confine the central bulge.[37] She should be instructed to inhale deeply and, while exhaling, raise her head to her chest until bulging is evident. This exercise can be done in bed in the morning and before sleep at night to keep maximum tone and to prevent progressive separation.

To strengthen the quadriceps, partial squats are a wonderful choice.[9] The patient may hold onto a supporting surface such as a chair back. She should be instructed to maintain good posture throughout these quadriceps strengthening exercises.

Fitness Program

Exercise facilitates muscle tone, strength, and endurance as well as contributing to an elevation of energy level, mood, and self image.[52] Staying active during pregnancy may also decrease associated discomforts including constipation, fatigue, bloating, swelling, and backaches.[1,54]

Before providing a pregnant woman with an exercise program, the physical therapist should have a knowledge base of some of the physiologic changes a pregnant woman undergoes. Cardiovascular changes include increases in blood volume, cardiac output, and the resting pulse along with a

decrease in systemic vascular resistance.[55] Respiratory alterations include a 50% increase in minute ventilation as a result of an increased tidal volume.[7] A reduced oxygen supply for aerobic exercise is dictated by an increased resting oxygen level along with the diaphragm working harder due to the enlarged uterus.[56] The thermoregulatory system is also affected. Heat production rises during pregnancy, although effects of exercise in regard to core temperature are limited.[56] The basal metabolic rate also rises requiring the woman to ingest about 300 extra kilocalories per day.[56]

Prior to initiating a fitness program, patients need to be assessed to determine appropriateness of an exercise regimen. A careful systematic history involving the cardiovascular, pulmonary, metabolic, and musculoskeletal mechanisms is essential. Contraindications to exercise during pregnancy are listed in Table 2.

Authors provide physical therapists with a number of guidelines pertinent to pregnancy and exercise.[54-56] Regular exercise performed at least three times per week is preferred over intermittent exercise. She may exercise at a mild to moderate intensity for up to 20 minutes at a time without allowing her heart rate to exceed 140 beats per minute. However, if the patient was active before pregnancy, she may exercise up to 30 minutes at a time.[54] After the first trimester, no exercises should be performed in the supine position because it is associated with a decrease in cardiac output.[55,56] All exercises incorporating the

Table 2.—Contraindications to Exercise[55,56]

1. Pregnancy-induced hypertension
2. Preterm rupture of membranes
3. Preterm labor during previous or current pregnancy
4. Incompetent cervix
5. Persistent second or third-trimester bleeding
6. Intrauterine growth retardation or macrosomia
7. Absence of prenatal care
8. Suspected fetal distress
9. Severe isoimmunization
10. Acute infectious disease
11. Recent pulmonary embolism
12. Rheumatic heart disease
13. Congestive heart failure
14. Active myocardial disease
15. Anemia or other blood disorder*
16. Thyroid disease*
17. Diabetes mellitus*
18. Breech presentation during third trimester*
19. Essential hypertension*
20. History of sedentary lifestyle*
21. Excessive obesity*
22. Extreme underweight*
23. Cardiac arrhythmia or palpitations*

*Relative contraindications = patients need to be medically supervised

Valsalva maneuver, ballistic movements, deep flexion or extension of joints, and any full sit-ups or double leg lowering activities should be avoided.

Particularly in the first trimester, maternal core temperature should not exceed 38° Celsius.[55,56] Women can promote heat dissipation by taking in adequate fluids, wearing appropriate clothing, exercising in an environment which is not hot or humid. She should also be reminded that an exercise program will increase her caloric intake requirements to exceed the additional 300 kilocalories.

A variety of exercise categories exist in which pregnant women may participate. Swimming is an excellent choice because it combines aerobic activity with non-jarring movements.[54,55] However, diving in the later months and scuba diving during any month of pregnancy is not advised.[54] Brisk walking is also a very good exercise especially for the beginning exerciser. If the woman jogged prior to pregnancy, it can be continued in moderation. Moderate games of tennis or doubles games are also acceptable exercises. The patient should be warned that sudden stops and her altered biomechanical posture may pose problems.[54] Bicycling may also be incorporated, preferably on a stationary bike to better accommodate changes in weight and balance as the pregnancy progresses.[55]

Women need to be educated in recognizing warning signs and symptoms of exercise related problems.[54,55] If any of the following signs or symptoms

occur, the patient should immediately stop exercising and contact her physician[54,55]:

1) pain
2) bleeding
3) dizziness
4) shortness of breath
5) palpitations
6) faintness
7) tachycardia
8) back or public pain
9) no fetal movement
10) contractions of the uterus
11) difficulty walking

All exercise programs for the pregnant client need to be specifically tailored for her. She will more than likely perform them at home or another unsupervised place requiring clear, and preferably, written instructions. Documentation of this patient education and the completed screening of contraindications are essential to avoid negligence claims.

Patient Education

A solid base of patient education is essential for implementation of successful physical therapy intervention. Education for the pregnant client should include information in posture, transfers, lifting, and the use of flat shoes.

Many authors advocate the use of flat shoes over high heels.[1,9,11,33,34] It is thought that high heels further displace the woman's center of gravity and accentuate her lumbar lordosis.[3] The theory is that high heels force the woman to thrust her pelvis forward, causing increased strain on ligaments of the back and hips and increased muscle work of the back and trunk to support the unstable posture.[6] However, one study of differing heel heights and their effects on the lumbar spine found that lumbar lordosis and pelvic inclination decreased with higher heels.[57]

Posture correction is critical in the prevention and reduction of back pain. When sitting, a pregnant woman should concentrate on decreasing her lumbar curve.[33] A chair with arms, a back rest inclined at 15°, and a footstool provide the best low back support.[1,33] A chair with these specific components is not always available; in such a case, the woman should be instructed to sit back in the chair and place her hands on her lap to allow for proper spinal alignment and the prevention of rounded shoulders.[6,33] Her feet should be placed flat on the floor or on a stool, but not tucked beneath her.[6] The use of pillows located at the lumbar spine and at the base of the neck provides additional support.[6,33] Upon rising from a chair, she should scoot close to the edge and push herself up utilizing her arms and legs as levers.

The goal of good standing posture is for the spine to form a small "S" curve around the center of gravity.[6] A pregnant woman should concentrate on keeping her pelvis tilted backward. This is accomplished by using her

abdominal muscles to pull the anterior pelvis upward and the gluteal muscles to keep the posterior pelvis down. "The pelvic angle is the key to comfort and support of the spine."[6]

Posture when lying down should also incorporate reduction of lumbar lordosis.[6,33,34] Many women feel most comfortable lying on their side.[33] In the right or left lateral recumbent position, the woman's cardiac output and circulation to the uterus and baby are maximized.[56,58] In contrast, the supine position after the first trimester impedes maternal and fetal blood flow. The enlarging uterus and amniotic fluid place pressure on the inferior vena cava and aorta causing a significant decrease in cardiac output,[22,56] thus causing the supine position to be contraindicated after the first trimester or after the fourth month of gestation.[25,56,58]

During the first trimester, a woman may find the supine position very comfortable with a pillow under knees. This position creates a rounded back.[33] She may also find a cervical pillow or a roll under her neck and the small of her back comfortable for maintaining normal spinal curves.[25]

In the sidelying position, a thin pillow can be placed lengthwise between her flexed legs to relieve tension in the low back and upper hip areas.[6] Further relaxation may be accomplished by tucking a pillow or rolled sheet under the abdomen. The uppermost arm should be supported on the pillow under her head while the other arm lies behind her.[6,25,33,58]

Prone lying is not ordinarily contraindicated at any time of pregnancy.[25] This position often relieves back pain because it anteriorly displaces the weight of the fetus and the amniotic fluid. The abdomen can be supported by using special pads with a tummy area cut out or by using a child's inner tube. Utilizing towel rolls or pillows under the ankles and forehead will support the feet and neck.

Every pregnant woman should be shown how to properly rise from a horizontal surface to avoid "jack knifing" and further separating or stretching of the rectus abdominis muscles. She should be instructed to flex her knees and roll to her side. Then she should use her arms to push herself into a seated position while slowly lowering her legs to the floor.[6,33] Before standing, she should rest momentarily.[33]

Proper body mechanics is necessary for preventing or relieving back discomfort. When lifting, she should not bend her back but utilize the muscles of her thighs and buttocks to do the work.[6] In this way, balance is improved because her center of gravity is lowered as she squats. Her feet should be spread apart with one foot placed slightly in front of the other. The weight should be born between her front foot and the ball of the back foot. It is also important for women to "limit their loads to arm's length values as soon as their girth begins to reduce reach."[24] Avoidance of high and low loads should also be taught since they shift the center of gravity and alter balance.

Rest

For many years, a conservative treatment for low back pain has been rest.[10] Although acute episodes of back pain respond to several days bed rest, recent years have seen a reduction in length of time of bed rest. However, longer periods of rest are still advocated for severe pain or in cases of neurologic deficit. "The role of bed rest beyond the acute phase is less clear, and chronic pain is unlikely to respond."[10]

Frequent rest periods with the foot of the bed elevated should be encouraged.[10,11] By elevating the foot of the bed, the head of the fetus slips out of the pelvis and the uterus falls upward. This allows reduction of lumbosacral plexes compression and venous congestion.[1,9] Another bed modification consists of using a firm mattress along with a half inch thick board to overcome the sagging effect of the springs.[1] These suggestions allow for more complete relaxation of the back musculature.

Manipulation

A rotational manipulation of the SIJ and lumbar spine has proven to be a safe and effective treatment option for the SIJ subluxations during pregnancy. To perform this type of manipulation, the patient should lie supine with the leg on the painful side flexed to 90° at the hip and the heel resting on the opposite knee.[22]

> The manipulator is positioned on the side contralateral to the raised leg with one hand on the shoulder ipsilateral to the raised leg and the other hand placed on the lateral aspect of the raised

> knee (right hand on the right shoulder and left hand on the right knee to manipulate the right SIJ). Pressure is then gradually applied to adduct the hip as far as possible, finishing with a sharp thrust.[22]

So far, no study has proven fetal risk due to a pelvic rotational manipulation.[22] Manipulation carries many positive attributes. It has very successful pain relief rates (91%). In addition, it is quick, not associated with chronic discomforts such as pelvic support belts, and can be done during any stage of pregnancy.[5,22] Manipulation offers an inexpensive and easily learned treatment choice for SIJ subluxation; yet many therapists are uncomfortable with this type of manipulation technique.[22] Caution should be used secondary to the loosening effects of relaxation on the joints and ligaments.[34]

Modalities

There is a wide variety of physical therapy treatments used for low back pain, but most are contraindicated during pregnancy. Due to concern of the effect of the electromagnetic field on the fetus, transcutaneous electric nerve stimulation is contraindicated with exception to its use for pain control in the second and third stages of labor.[10,34,59] Therapeutic ultrasound, which operates at a higher energy and intensity level as compared to diagnostic ultrasound, is not advised for use near the pelvis during pregnancy.[9,29,59] Other contraindicated modalities include shortwave diathermy and other electrical treatments. Massage and moist heat are beneficial in the relaxation of tight muscles by

increasing the blood supply.[10,35] However, they are also contraindicated if the woman possesses medical problems such as thrombophlebitis.

Whirlpools, Hubbard tanks, and saunas need to be used with extreme caution. Water temperatures should be carefully monitored because an internal increase of one degree Fahrenheit may expose the fetus to extreme heat and pose problems in cell division.[60]

Use of an Orthosis

Utilization of an orthosis can be helpful in decreasing low back discomfort mainly due to SIJ problems or in the case of diastasis recti. A pelvic belt produces increased pelvic stability by providing more friction at the SIJ surfaces.[31] The belt should be worn just cranial of the symphysis or just above the greater trochanter.[32] The patient has the freedom to adjust it as necessary to meet her demands. These belts were also successful in reducing posterior pelvic pain associated with increased movement and activity. However, use of a pelvic belt has not been correlated with a reduction in static pain.[4] Lumbosacral corsets are prescribed for SIJ symptoms that do not resolve two to five months post-partum.[3]

An orthosis to help approximate the bellies of the rectus abdominis has also been used by women.[39] The corset must allow for growth of the uterus. A comfortable, yet molded fit can be achieved by using Velcro and elastic material. It is important that the corset provide some compression over the anterior

abdominal wall and an upward lift. An added bonus for the use of this type of corset is that it can also be employed during delivery of the baby.[39]

It is important to recall that the use of any orthosis is not a monotherapy. In fact, the substitution of an orthosis without abdominal strengthening exercises may actually weaken abdominal musculature with overuse.[34] Simultaneous muscle training of the abdominal and gluteal muscles will enhance the benefits of an orthosis.[31]

Physical therapists own a huge arsenal of treatment options for pregnant women suffering from low back discomfort. Lines of communication between the patient and the physical therapist must be kept open during and after treatment to provide answers to questions and provide reassurance. Communication with the patient's physician or midwife will keep them informed as well as provide continuity in overall patient care. It is important to employ independence in all possible treatment mechanisms for the benefit of the patient. With the inception of managed care, it is imperative from a cost effective standpoint to maintain the health and well being of the patient. Education, leading to the implementation of independent self care, is the goal of successful intervention.

CHAPTER V

CONCLUSION

Pregnancy is a time of eager anticipation for the birth of a new family member. Unfortunately, at least a portion of pregnancy is often marred by the occurrence of low back or posterior pelvic pain. Women have considered this type of pain a normal and expected adjunct of pregnancy for many decades. However, a review of the literature provides valuable information on the treatment and prevention of such a problematic discomfort.

This independent study has reviewed the etiologies of pregnancy related low back pain including mechanical, hormonal, and vascular causes. Differentiation and specific evaluation techniques of low back pain were also addressed along with a number of possible physical therapy interventions. A physical therapist can help alleviate or prevent some types of low back pain by incorporating exercise, patient education, modalities, manipulation, and/or the use of an orthosis.

After reviewing the literature, it is easy to see a lack of research and documentation in the area of pregnancy related low back or posterior pelvic pain. Causes of low back discomfort are not clear-cut. The process of differential diagnosis is often difficult and confusing due to interrelated factors.

Exercise is an excellent modality to choose as an intervention, regardless of specific etiology. By utilizing exercise, strength, posture, muscle balance, and cardiovascular fitness can be addressed as components in the treatment and prevention of low back pain.

The field of obstetrical physical therapy is growing, and yet many physical therapists are apprehensive of treating pregnant clients. Knowledge of physiologic processes, mechanics of low back pain, and associated contraindications during pregnancy may alleviate this worry and are crucial in constructing an appropriate intervention plan. A compliant patient and knowledgeable physical therapist, in combination with the physician or midwife, form an effective team in reducing and possibly preventing low back pain during pregnancy.

REFERENCES

1. Cherry SH, Berkowitz RL, Kase NG, eds. Rovinsky and Gattmacher's Medical, Surgical, and Gynecological Complications of Pregnancy. 3rd ed. Baltimore, Md: Williams and Wilkins; 1985:422-431.

2. Orvieto R, Achiron A, Ben-Rafael Z, Gelernter I, Achiron R. Low back pain of pregnancy. Acta Obstet Gynecol Scand. 1994;73:209-214.

3. Rungee MA. Low back pain during pregnancy. Orthopedics. 1993;16:1339-1344.

4. Ostgaard HC, Zetherstrom G, Roos-Hansson E, Svanberg B. Reduction of back and posterior pelvic pain in pregnancy. Spine. 1994;19:894-900.

5. King-Piu Fung B, Man-Fung Kwong C, Shih-Chu Ho E. Low back pain of women during pregnancy in the mountainous district of central Taiwan. Chin Med J. 1993;51:103-106.

6. Ostgaard HC, Andersson GBJ, Karlsson K. Prevalence of back pain in pregnancy. Spine. 1993;18:61-64.

7. Artal R, Wiswell R, Roman Y, Dorey F. Pulmonary response to exercise in pregnancy. Am J Obstet Gynecol. 1986;154:378-383.

8. Paul JA, VanDijk FJH, Frings-Dresen MHW. Workload and musculoskeletal complaints during pregnancy. Scan J Work Environ Health. 1994;20:153-159.

9. Epstein JA. Treatment of low back pain and sciatic syndromes during pregnancy. New York J Med. 1959;5:1757-1768.

10. Alexander JT, McCormic PC. Pregnancy and discogenic disease of the spine. Neurosurg Clinics of North America. 1993;4:153-158.

11. Spankus JD. Cause and treatment of low back pain during pregnancy. Wisconsin Med J. 1965;64:303-304.

12. Fast A, Weiss L, Ducommun EJ, et al. Low-back pain in pregnancy abdominal muscles, sit up performance, and back pain. Spine. 1990;15:28-30.

13. Svensson HO, Andersson GBJ, Hagstad A, Jansson PO. Relationship of low-back pain to pregnancy and gynecologic factors. Spine. 1990;15:371-375.

14. Melzack R, Belanger E. Labour pain: correlations with menstrual pain and acute low-back pain before and during pregnancy and gynecologic factors. Spine. 1990;15(5):371-375.

15. Young J. Relaxation of the pelvic joints in pregnancy: pelvic arthropathy of pregnancy. J Obstet Gynec. 1940;47:495-524.

16. Walker J. The sacroiliac joint: a critical review. Phys Ther. 1992;72:903-915.

17. Berezin D. Pelvic insufficiency during pregnancy and after parturition. Acta Obstet Gyn Scand. 1954;33(suppl 3):9-39.

18. Black S, Anastasi SC. Pregnancy and the lower extremities. Biomechanics. 1995;4:22-28.

19. McIntosh J. Women—the captive audience. Physiotherapy. 1989;75(1):10-13.

20. Hansen K. Sacrococcygeal instability in pregnancy. J Ob/Gyn PT. 1993;17(4):5-7.

21. Gabbe SG, Niebly JR, Simpson JL, eds. Obstetrics—Normal and Problem Pregnancies. 2nd ed. New York, NY: Churchill Livingston; 1991:228.

22. Daly J, Frame PS, Rapoza PA. Sacroiliac subluxation: a common treatable cause of low back pain in pregnancy. Fam Practice Research J. 1991;11(2):149-159.

23. Ganong WF. Review of Medical Physiology. 16th ed. Norwalk, Conn: Appleton and Lange; 1993:375.

24. Goodwin E, Aston G. Pregnancy clauses. Nsg Times. 1994;90(43):56-58.

25. Prentice C, McCue Canty A, Janowitz I. The pregnant patient and her partner. Occupational Medicine. 1992;7(1):77-85.

26. Ostgaard HC, Andersson GBJ, Karlsson K. Prevalence of back pain in pregnancy. Spine. 1993;18(1):61-64.

27. Ostgaard HC, Andersson GBJ, Schultz AB, Miller JAA. Influence of some biomechanical factors on low-back pain in pregnancy. Spine. 1991;16(5):549-552.

28. Cunningham GF, MacDonald PC, Grant NF. Williams Obstetrics. 18th ed. Norwalk, Conn: Appleton and Lange; 1989:271.

29. Wilder E, ed. Clinics in Physical Therapy: Obstetric and Gynecologic Physical Therapy. Vol. 20. New York, NY: Churchill Livingston; 1988.

30. Golighty R. Pelvic arthropathy in pregnancy and the puerperium. Physiotherapy. 1982;68(7):216-220.

31. Vleeming A, Buyruk HM, Stoeckart R, Karamursel S, Snijders C. An integrated therapy for peripartum pelvic instability: a study of biomechanical effects of pelvic belts. Am J Obstet Gynecol. 1992;166(1):1243-1247.

32. Vleeming A, Volkers ACW, Snijders CJ, Stoeckart R. Relationship between form and function in the sacroiliac joint part II: biomechanical aspects. Spine. 1990;15(2):133-136.

33. Maring-Klung R. Reducing low back pain during pregnancy. Practitioner. 1982;Nov-Dec:18-24.

34. Gleeson PB, Pauls JA. Obstetrical physical therapy review of literature. Phys Ther. 1988;68(11):1699-1702.

35. Bushnell LF. The postural pains of pregnancy. Western J of Surgery, Obstetrics, and Gynecology. 1949;123:123-127.

36. Boissonnault JS, Blaschak MJ. Incidence of diastasis recti abdominis during the childbearing year. Phys Ther. 1988;68(7):1082-1086.

37. Noble E. Essential Exercises for the Childbearing Year. 3rd ed. Boston, Mass: Houghton Mifflin Company; 1988.

38. Porterfield JA, DeRosa C. Mechanical Low Back Pain - Perspectives in Functional Anatomy. Philadelphia, Pa: WB Saunders Co; 1991.

39. Thorton SL, Thorton SJ. Management of gross divercation of the recti abdominis in pregnancy and labor. Physiotherapy. 1993;79(7):457-458.

40. Fast A, Weiss L, Parikh S, Hertz G. Night backache in pregnancy: hypothetical pathophysiological mechanisms. Am J Phys Med Rehabil. 1989;68:227-228.

41. Fast A, Shapiro D, Ducommun EJ, Friedmann LW, Bouklas T, Floman Y. Low back pain in pregnancy. Spine. 1987;12:368-371.

42. Fast A, Hertz G. Nocturnal low back pain in pregnancy: polysomnographic correlates. Am J Reprod Immunology. 1992;28:251-253.

43. Hertz G, Fast A, Feinsilver Sh, et al. Sleep in normal late pregnancy. Sleep. 1992;15(3);246-251.

44. Ben-David Y, Bornstein J, Sorokin Y, Morad E, Abramovici H. Transient osteoporosis of the hip during pregnancy: a case report. J Reprod Med. 1991;36(9):672-674.

45. Magee DJ. Orthopedic Physical Assessment. 2nd ed. Philadelphia, Pa: WB Saunders Co; 1992.

46. Artae Mittlemark R, Wiswell RA, Drinkwater BL, eds. Exercise in Pregnancy. 2nd ed. Baltimore, Md: Williams and Wilkins; 1991.

47. Rhodes P. Orthopaedic conditions associated with childbearing. Practitioner. 1958;181:304-312.

48. Ostgaard HC, Zetherstrom G, Roos-Hansson E. The posterior pelvic pain provocation test in pregnant women. Eur Spine J. 1994;3:258-260.

49. Bookhout MR, Bookhout MM. Physical therapy treatment for low back pain. J Back Musculoskel Rehabil. 1991;3:7-15.

50. Bookhout MM. Exercise for Maintaining Musculoskeletal Health During Pregnancy. Presented at 1994 American Physical Therapy Association sponsored National Student Conclave; October 30, 1994; Minneapolis, Minn.

51. Andrews CM, O'Neill LM. Use of pelvic tilt exercise for ligament pain relief. J Nurse-Midwifery. 1994;39(6):360-374.

52. Hartman RE. Exercises for True Natural Childbirth. New York, NY: Harper and Row, Publishers Inc; 1975:53-61.

53. Shearer M. Teaching prenatal exercise: part I. posture. Birth and Fam J. 1981;8:105-108.

54. American College of Obstetricians and Gynecologists. Exercise and Fitness: A Guide for Women. Washington, DC: ACOG; December 1992.

55. Artal Mittlemark R, Wiswell RA, Drinkwater BL, eds. Exercise in Pregnancy. 2nd ed. Baltimore, Md: Williams and Wilkins; 1991.

56. American College of Obstetricians and Gynecologists. Exercise during pregnancy and the postpartum period. ACOG Technical Bulletin 189. Washington, DC: ACOG; 1994.

57. Bendix T, Sorensen SS, Klausen K. Lumbar curve, trunk muscles, and line of gravity with different heel heights. Spine. 1984;9:223-227.

58. Frahm J, Davis Y, Welch RA. Physical therapy management of the high risk antepartum patient. Clin Manage. 1991;9(5):47-49.

59. Griffen JE, Karselis TC. Physical Agents for Physical Therapists. Springfield, Ill: Charles C. Thomas; 1987.

60. Simkin P, Whalley J, Keppler A. Pregnancy, Childbirth and the Newborn. Deerhaven, Minn: Meadowbrook Press Inc; 1984:73.